TURNER (TH. J.)

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A FRAGMENT OF APPLIED PHYSIOLOGY.

By TH. J. TURNER, A. M., M. D., Ph. D.,

MEDICAL INSPECTOR UNITED STATES NAVY.

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(SECOND EDITION.)

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In the report of the Bureau of Equipment and Recruiting for the year 1877, made to the honorable Secretary of the Navy, by its chief, Commodore R. W. Shufeldt, U. S. N., the importance of a more efficient ventilation of ships of war was commented upon and recommendations made toward securing a larger supply of air to the lower decks of our vessels than now obtains.

A chart exhibiting the cubic air-space for each officer and man on board of three vessels taken as the exponents of the various rates in the service was appended to this report.

In this chart the cubic air-space in vessels of the Swatara class equals 324 cubic feet for each officer, 58 cubic feet for each man, with a complement of 25 officers and 180 men; in those of the Richmond class, 273 cubic feet per officer, and 68 cubic feet per man, with a complement of 34 officers and 285 men; in vessels of the Miantonomoh rating, 1,158 cubic feet per officer and 81 cubic feet per man, with a complement of 13 officers and 171 men.

These numbers of cubic feet per person are obtained by dividing the total cubic air-space on the lower deck by the complement of officers and men.

The object of a portion of this paper is to exhibit and demonstrate from official data, physiologically considered, the inefficiency of the present as well as the necessity that obtains for a better ventilation.

It is obvious that the number of the crew of a vessel of war is determined by the requirements of the battery and the handling of the ship, and in the instances named limited air-space or overcrowding is an unavoidable consequence.

The Revised Statutes of the United States, paragraph 4252, assigns to each passenger on a main or poop deck 16 clear superficial feet; if the decks are 6 feet in the clear, 18 clear superficial feet on lower decks; no passenger to be carried where the decks are less than 6 feet in the clear; and where the decks are 7½ feet or more in the clear, 14 superficial feet is the allowance.

The British merchant shipping act assigns 72 cubic feet and 12 superficial feet on deck for each person as the minimum space. These measurements we must accept provisionally as a standard.

This unavoidable overcrowding follows its usual law in increased sick and death rates.

How soon the air on these lower decks becomes unfit for the purposes of respiration and consequently detrimental to health, will be made evident from the following facts: The normal amount of carbon-dioxide existing in the atmosphere is accepted at 4 volumes in 10,000, and the limit of respiratory impurities, as measured by the increased volume of this gas, is stated by the best authorities to be 6 volumes in 10,000. It must be stated here, with the hope that it may be distinctly understood, that carbon-dioxide is used as the *measure* of the impurity of the air, not on account of its own special poisonous action, but because (and I quote the words of Billings) "within certain limits its quantity may be taken as the measure of that of really important impurities, and it is almost the only available test for this purpose."

The observations of Pettenkofer and Voit, Zoch, Donkin, Parkes, De-Chaumont, repeated by the writer, amount to an absolute demonstration of this fact.

Now, in 50 cubic feet of *still* air this limit of impurity is attained by the respiration of a single individual in one minute of time.

It follows, therefore, that in vessels of the Swatara class, under like conditions, the limit is arrived at in 1′.16; in those of the Richmond class, in 1′.36; and in those of the Miantonomoh class, in 1′.52.

These circumstances, however, seldom or ever obtain, for in masses of men engaged in work in confined spaces, with a slow-moving air, conditions existing in a degree on shipboard, the limit of atmospheric impurity is much sooner attained, for the amount of CO_2 eliminated from the body by respiration alone being more than doubled in passing from a state of rest to performing work equivalent to walking one mile per hour; that is to say, a man weighing 160 pounds, *at rest*, expires per hour .716 of a cubic foot of carbon-dioxide; walking one mile per hour, 1.446 cubic feet; walking 2 miles per hour, 2.53 cubic feet; and should the work done be equal to walking three miles per hour, the most useful rate of work, considering the element of time, 3.275 cubic feet of carbon-dioxide is expired.

As a general rule, it may be stated that about 8 cubic inches of CO^2 are given off per hour for each pound avoirdupois weight of the individual when at rest.

As most of our cruising stations are within climates having tropical characteristics, it must be stated here that the effect of increased temperature is to diminish the exhalation of CO_2 from the lungs. The importance of this physiological fact will be seen presently.

The ratio of the inspired air is increased under the circumstances of work.

With these facts, the limit of atmospheric impurity in the vessels cited as examples is attained in less than one minute of time, and it follows as a consequence that on their berth-decks there is not a cubic foot of air normal in quantity at any one instant from the time they are put in until the going out of commission, and this notwithstanding the law of diffusion, upon which their ventilation in a great degree depends.

In the statement first made, the amount of carbon-dioxide resulting from the combustion of fuel or from lights, &c., is excluded; that from the respiratory and cutaneous systems being alone considered.

As demonstrating the varying amounts of this gaseous impurity in the air of the vessels of the Navy, I have to call attention to the recorded observations now in the Bureau of Medicine and Surgery, whose accuracy is established over the signatures of the various medical officers observing.

Thus on the berth-deck of the Powhatan, while at Norfolk and New York, during the months of April, May, and June, the amount of carbon-dioxide ranged from 11.8 to 19.6 volumes per 10,000, the observations being made generally about 11 p. m. No registration on this vessel ever reached the normal.

On the Swatara, one of the vessels cited as an example, for the same period, at sea and in port, the range was from 15.03 to 26.62 per 10,000 volumes, and no registration ever approached the normal.

On the Ossipee the range was from 14 to 18 volumes per 10,000. The Saint Louis, Franklin, Minnesota, Alaska, Plymouth, Colorado, &c., all present frequent observations, in some near and in all exceeding the limit.

The highest amount of carbon-dioxide recorded gives 39.1 volumes per 10,000, an amount exceeding those found by Rattray and Hayne.

Considering these recorded results in excess of the limit, as the measure of the organic impurities in the atmosphere, the remarks of Simon are not inappropriate as describing the condition of the air on the berth-decks of some of our vessels: "The foulness of the air due to the non-removal of the volatile refuse of the human body is as entirely within the physiologist's definition of filth and as truly a nuisance within the scope of sanitary law as the non-removal of solid or liquid refuse."

It seems hardly necessary to repeat that pure air is the absolute constant requirement of health and life.

Impure air and overcrowding lowers the tone of vitality, abridges life, and favors the spread of zymotic diseases. They are the parents of wasting lung-disorders and of scrofula, and give to their sickly children

in the future the inheritance of unproductive labor with its accompanying poverty and crime. They shorten the life of the sailor, and they must be added to those causes suggested by Brassey and Forbes of the decline of the British and American seamen; for this skilled labor, this art and mystery of a mariner, has begun to be considered as in a decay.

The great sick-rates and consequent lessened average duration of life of these selected men of the sea are mainly dependent upon impure air, overcrowding, and humidity. Steam has demanded its tribute in these directions also, as well as the tardy footsteps of discipline in the advancement of sociology.

Of the diseases produced or aggravated by impure air the record increases steadily. All the zymotic diseases, as has been stated, are included in the list, but more particularly are those affections of the pulmonary tissues described as wasting lung-disease or grouped as cases of phthisis pulmonalis.

It is hardly necessary to state that typhus has a synonym in ship-fever, or to recall that its origin and propagation and fatality alike are dependent upon filthy air from overcrowding.

The observations of Rattray, Muir, Blake, MacCormac, Bowditch, Welch, and others have made this evident.

Carmichael (1810) has shown the connection between impure air and scrofula; Parent du Chaletet that venereal affections are aggravated by impure air; Chadwick that impure air is a factor in producing habits of intemperance, and I have heard it stated that an eminent captain in our service has observed that most of the quarrels arising on shipboard occur in the morning watches, when the men turn out from their stuffy, air-poisoned decks, thus exhibiting the toxic effect of impure air in a lower *morale* from depressed cerebration. Air—fresh air—its necessity is the constant iteration of every sanitary observer. It is the essential of life—more necessary than food or water; a man may go days without either, but not five minutes without air.

Accepting the overcrowding and limited air-space as unavoidable, the condition of imperfect ventilation resulting therefrom has been sought to be remedied by the plan proposed in the report of a board convened by order of the honorable Secretary of the Navy, composed of Commander J. R. Bartlett, Chief Engineer D. Smith, Naval Constructor F. L. Fernald, and the writer. This report was made in May, 1878, was approved by the department, and referred to the Bureaus of Construction and Steam-Engineering, respectively.

The plan proposed in this report is susceptible of alteration and adaptation to vessels of any class or size. It is simply a modified form of the Napier system of ventilation, having its basis in the plainest application of the statics and dynamics of the air.

It answers the essential conditions called for in all ventilation—the maintenance of the air which fills the necessary cubic space allotted at such a degree of purity (*i. e.*, normal external air) as to keep it free from danger to health of those who habitually breathe it.

Thus much briefly for the air in its constitution as affecting the health of seamen.

In a much greater degree is *dryness* of the air an *essential* requirement for the health of the sailor.

The amount of CO_2 being taken as the measure of aerial impurity, it has been observed by Angus Smith that its volume is increased in *moist* air. Lehmann says "the weight of carbonic acid excreted in moist air greatly exceeds that eliminated in a dry atmosphere." It has already been observed that the effect of an increased temperature is to diminish the exhalation of CO_2 from the lungs. Now, the influence of moisture is so great that at high temperatures it neutralizes the effect of such temperature in diminishing the elimination of CO_2, which under such circumstances is retained in the system. Again, as a general rule the expired air is saturated with moisture so that when the temperature of the air comes to be the same as the temperature of the body and saturated, no exhalation of aqueous vapor from the skin and lungs is possible; and there is also retained, from that fact, within the body, the excreta from these organs. It is evident that life cannot be prolonged in such an air at a temperature between 90° and 100° F.

With a temperature above 80° air of excessive humidity is injurious, and yet in tropical climates such humidity is sought for by the constant wetting of the decks. The natural humidity of the air on decks at sea, or anywhere else, should never be supplemented by artificial means to render it saturated.

The writer is of the opinion from observations of his own that the aqueous vapor in the air is the solvent and carrier of the CO_2, as well as the vehicle for organic matter; and he is led to believe that in determining the purity of the air by CO_2 the relative humidity at the time the observation is made should always be associated. By such grouping the value of this test is much increased, and he hazards the suggestion that it is the want of such connection which has led to the few discordant results by this method of air examination.

The atmospheric observations before referred to, as well as those of the writer, abundantly confirm the fact of the excessive humidity of the air on shipboard. In these observations the relative humidity of the open air on the spar-deck has been assumed as the *unavoidable* as well as the standard of comparison with the relative humidity of the other decks.

The excess over such standard, when it occurs, may be considered as the preventable humidity. It is not an unfrequent occurrence on dry ships, and indeed it must be considered characteristic of them, to find the relative humidity on the inclosed decks less than that of the open air. It is well to remember in all these observations the physical law that the capacity of the air for moisture increases in a geometrical ratio with its temperature, and that for every 27° F. rise in temperature the capacity of the air for moisture is doubled; and also that air is dry or moist, not in proportion to the amount of water it contains, but in pro-

portion as it is more or less removed from saturation. As examples of the relative humidity of the air on shipboard, without any relation to the other associated physical phenomena, the following are presented:

Powhatan.—Average for June, 1878:

	Relative humidity.
Spar-deck	89
Berth-deck	97

The spar-deck was wet twenty-eight and the berth-deck nine times in the thirty days.

Swatara.—Average for June, 1878:

	Relative humidity.
Spar-deck	75
Berth-deck	79

The spar-deck was washed two and the berth-deck seven times in the month.

The registrations can readily be supplemented for other months and for other vessels.

Through the favor of Assistant Surgeon J. A. Tanner, jr., U. S. N., the writer has been furnished with a copy of the observations made on board the tug Mayflower during part of August and September of the present year, from which the following abstract is made: "The spar-deck" of this vessel "is washed down regularly every morning. The berth-deck and steerage are coated with shellac and regularly swabbed."

Deck.	Hours.					
	10 a. m.		4 p. m.		10 p. m.	
	Temperature.	Relative humidity.	Temperature.	Relative humidity.	Temperature.	Relative humidity.
Spar	21	82	22	76	21	80
Berth	23	79	23	78	23	79

Temperature in centigrade. Relative humidity, saturation = 100.

Now, the amount of aqueous vapor given off from the lungs and skin varies in a person at *rest* and under certain conditions, but may be assumed as an average from 30 to 32 ounces per diem, or from 550 to 584 grains per hour, enough to saturate from 90 to 100 cubic feet of air; at *work*, about 68 ounces, or 1,240 grains per hour, enough to saturate 200 cubic feet of air at the normal temperature and pressure of 62° F., 30 inches barometer.

The number of heat units required to evaporate this amount of water belongs to the subject of the temperature of the air and the body. These quantities, it will be perceived, are sufficient—considering the crews and their allotted air-space in the vessels cited—to saturate with watery vapor, carrying decomposing organic matter, all that space, without resort to any other means.

The excessive humidity of the air on the lower decks has its origin

almost entirely in the daily water-soaking routine which exists in the service, and to which the decks are subjected.

If this routine washing, holy-stoning, wiping, clamping, scrubbing, &c., is meant for cleanliness, an obvious inference therefrom would disrate the Augean stables from their billets as the pre-eminent examples of filth and our vessels would be promoted to that unenvied rating.

If it is not meant for cleanliness, then, in the light of modern scientific research, it is the ruthless and barbarous wielding of a potent disease-producing weapon against the lives of the unoffending and powerless.

The daily routine of vessels in service furnishes ample evidence that the decks are constantly saturated. The following copies of the routine, so far as relates to the wetting of decks, are made from original written or printed documents:

Monday.—Scrub off all decks with sand.

Tuesday.—Holy-stone all decks.

Wednesday.—Scrub off decks.

Thursday.—Scrub decks with sand; holy-stone forward and after passage.

Friday.—Scrub decks without sand.

Saturday.—Holy-stone all decks.

Sunday.—Wash off all decks.

TENNESSEE.

Again:

SUMMER.

Monday.—Scrub decks, &c., with sand.

Tuesday.—Scrub spar-deck without sand.

Wednesday.—Scrub decks, &c., without sand.

Thursday.—Scrub spar-deck without sand.

Friday.—Scrub decks with sand.

Saturday.—Holy-stone decks, &c.

Sunday.—Scrub decks without sand.

WINTER.

Monday.—Scrub decks, &c.

Tuesday.—Scrub spar-deck.

Wednesday.—Scrub decks, &c.

Thursday.—Scrub spar-deck.

Friday.—Scrub decks, &c.

Saturday.—Holy-stone decks.

Sunday.—Scrub decks.

MINNESOTA.

Again:

Monday.—Scrub decks.

Tuesday.—Scrub decks without sand.

Wednesday.—Holy-stone decks.

Thursday.—Scrub spar-deck without sand.

Friday.—Scrub decks with sand.

Saturday.—Holy-stone decks.

Sunday.—Scrub decks with sand.

The above outline is given, subject to the approval of the commanding officer. [New W. Q. & Stn. bills printed.]

Or the following summaries from official papers:

Wyoming.—August: Spar-deck wet 4, berth-deck 31 times.

Ossipee.—December: Spar-deck every morning when not raining, berth-deck 6 times.

Enterprise.—June: Spar-deck wet 30, berth-deck 10 times.

Plymouth.—June: Spar-deck wet 26, berth-deck 6 times.

Saint Louis.—June: Spar-deck wet 30, berth deck 4 times.

And in one first-rate during the month of June all decks are reported dry on two occasions.

There appears, therefore, a capriciousness in this matter which should not exist.

In some instances that have come to the knowledge of the writer this wetting of the decks has been delegated to the petty officers of the ship, and has been determined upon by some oracular Bunsby, whose opinions are founded upon the way they used to do in those "good old times" to which he so fondly reverts and in which he so implicitly believes.

The whole practice is a relic of those days—of the days of Paul Hoste, Benbow, Van Tromp. Indeed, the inheritance is Noachian, and it seems to be an effort of such heredity in this direction, midst others, to reproduce the exact conditions of that memorable cruise on shipboard to-day. Otherwise it is difficult at the present time, considering the progressive development of the Navy, to understand why this abomination is so strenuously upheld. It would soon cease—

> Had not damned custom brazed it so
> That it be proof and bulwark against sense.

For those who may desire some few data for guidance in these matters, it may be stated that a relative humidity should not vary much from 70 to 75. The average relative humidity of the air over the world, according to Lévy, being 72, may be assumed as the normal. The difference between the dry and wet bulb thermometers should not be less than 3° or 4° F. Briggs, the best authority upon atmospheric moisture, assigns 70 as the relative humidity in our country as best consistent with health. The air over the ocean has always a greater degree of relative humidity than over the land, and varies slightly in summer and winter. The range has been determined as from 70 to 75, saturation = 100.

The less also the cubic air-space per man, the greater becomes the relative humidity of the air.

The diurnal and seasonal variation and range of relative humidity seems positive from the observations before alluded to, but whether it follows the cyclical oscillations of the barometer and thermometer, as

might be supposed, has not yet been determined. Future registrations may develop the law governing its periodicity.

It may be well here to allude to the point of comfort of the external temperature. This varies, but the range assigned by numerous observers is from 58° to 68° F.

All writers on etiology are agreed upon the disease-engendering effects of humidity of the air.

In 1792, Clark, in writing upon the diseases of long voyages, remarks: "The diseases occasioned at sea by heat united with moisture are fevers and fluxes"; and when treating of the means of obviating the ill effects of heat, coldness, and moisture, says, in the conclusion of his article, "to dry up all moisture by placing stoves in various parts between decks."

Welch, assistant professor of pathology at Netley in the Alexander prize-essay says: "The main deleterious property of the general atmosphere is moisture." Again, speaking of the excess of watery vapor in the air: "According as it approaches saturation, it (*i. e.*, the air) tends to impede the exhalation from the lungs and favors congestion. Beyond this, also, the intimate connection between organic matter and hygrometric bodies must not be forgotten."

Simon, speaking of filth ferments, states that "they show no power of diffusion in dry air, but, as moisture is their normal medium, currents of humid air can doubtless lift them in their full effectiveness."

C. B. Fox remarks in his late book (1878) as follows: "Aqueous vapor possesses a powerful affinity for organic matter, and serves both to preserve and diffuse it." Again: "An excess of aqueous vapor has not only a depressing effect upon the nervous system, but it interferes with the pulmonary and cutaneous exhalations."

"Humidity," says Pringle, "is one of the most frequent causes of the derangement of health."

Fonssagrives, the authority on naval hygiene, asserts that "a damp ship is an unhealthy ship." The researches of Rouppe, Kerauden, Raoul, Bourel-Ronciere, and others, all tend to exhibit the disease-producing influence of this aerial condition.

Wagner, in his Manual of General Pathology, thus alludes to the moisture of the air: "Warm and damp air most impedes the radiation of heat from the body through the skin and lungs, causes exhaustion of the muscular and nervous systems, restrains respiration, diminishes the appetite, impairs the digestion, and increases the perspiration."

Sir Alexander Armstrong, the present head of the medical department of the English navy, says: "There can be no more fertile source of disease among seamen, or indeed other persons, than the constant inhalation of a moist atmosphere, whether sleeping or waking; but particularly is this influence injurious when the moisture exists between a ship's decks, where it may be at the same time more or less impure, and hot or cold according to circumstances."

It is hardly deemed necessary here to exhibit the influence of humidity in the production of the miasmata.

As to its bearing the relation of causation to wasting lung diseases or phthisis and scrofula, Alison, Baudelocque, Ransome, MacCormac, Carmichael, Bowditch, Buchanan, and others, all bear testimony to vitiated and moist air as being the most important factor in their production.

It may be well to observe here that most of the cases of phthisis in our service, whose hospital tickets are so frequently indorsed as not originating in the line of duty, have, considering the care taken in recruiting, their origin directly in the line of duty, from breathing impure, damp air. Trotter remarks in his Medicina Nautica: "The nature of cleanliness is often misunderstood, and I know of nothing of that kind which is so much mistaken as the too frequent and indiscreet drenching the decks, and more especially those where people sleep, with water. By this means I have known dreadful sickness *introduced*, and I have known it removed by a contrary practice. It would be deemed extravagant to advance an opinion that the decks should *never* be washed, but I feel no reluctance in making a direct assertion that it were far better that they should not be *washed at all* than with that want of discretion and precaution which so generally prevails. It has caused the death of thousands."

Guy, W. A., speaking of vessels like the Centurion and others of that date, describes them as "damp, filthy, and ill ventilated," and the history of the cruise of the Centurion reads to-day like a romance. "In nine months her crew of 506 was reduced to 214," &c., from cold, damp, and scurvy. The health histories, however, of such vessels as the St. Jean d'Acre, Neptune, Caledonian, London, Renown, Black Prince, and others in the English navy, and of some of our own, reveal the extent of this nuisance in deteriorating the health of the crews.

Amidst the diseases induced and aggravated by excessive humidity centrally stand those of the pulmonary organs, with phthisis and other wasting diseases of these tissues, and around them scurvy, rheumatism and its associated cardiac trouble, abscesses, felons, boils, and diseases of the subcutaneous cellular system are grouped.

Statistics confirm these statements. Thus, on the home and foreign stations for the year:

1872.—Total number of men, 11,570; total cases treated, 9,207; deaths, 61.

	Cases treated.	Deaths.
Respiratory system	1,020	18
Integumentary system	1,092	1

1873.—Total number of men, 12,723; total cases treated, 8,837; deaths, 55.

	Cases treated.	Deaths.
Respiratory system	896	10
Integumentary system	1,023	0

1874.—Total number of men, 13,870; total cases treated, 9,995; deaths, 64.

	Cases treated.	Deaths.
Respiratory system	1 089	12
Integumentary system	1,068	0

1875.—Total number of men, 10,141; total cases treated, 7,832; deaths, 49.

	Cases treated.	Deaths.
Respiratory system	718	11
Integumentary system	828	0

1876.—Total number of men, 11,138; total cases treated, 7,797; deaths, 41.

	Cases treated.	Deaths.
Respiratory system	558	9
Integumentary system	914	2

It is of importance to remember that the crews of vessels of war are examined as to their physical qualifications, and that these sick and death rates represent such rates of chosen and picked lives.

Contrast on the other hand the records of dry ships, few in number, for this evil of dampness is widespread in all navies, and mark the evident result of the inspection.

Collingwood's flag-ship, with a crew of 800 men, kept the seas for more than a year and a half with never more than six on her sick-list. This low rate was secured by attention to dryness, ventilation, and a general care of the crew.

Admiral Foote diminished the large sick-lists of the Varuna, caused by excessive wetting of the decks, by abating the nuisance.

Medical Director Maxwell's suggestions being carried out saved the crew of the Powhatan, in China, under like circumstances.

Admiral Boggs, when commanding the mail-steamer running from New York to Aspinwall, escaped malarial poisoning by keeping his cabin dry.

Sir Gilbert Blane very early suggested that cleanliness and dryness were of importance in preserving the health of seamen.

Trotter, when physician to the fleet of Lord Howe, rendered that fleet effective by his attention to dryness of the vessels, midst other sanitary measures. To use the words of Guy, "he helped to organize victory" by placing in the hands of his gallant chief the living material of the fleet in a state of first-rate efficiency.

The record of Captain Murray, R. N., of H. B. M. S. Valorous, exhibits the value of dryness on board ships beyond cavil or doubt: "That when, on his arrival in England, in 1823, after two years' service amid the icebergs of Labrador, the ship was ordered to sail immediately for the West Indies, * * * he proceeded to his station with a crew of 150 men; visited almost every island in the West Indies and many of the ports in the Gulf of Mexico; and, notwithstanding the sudden transition from extreme climates, returned to England without the loss of a single man." He also adds "that every precaution was used, by lighting stoves between decks and scrubbing with hot sand, to insure the most thorough dryness. When in command of the Recruit gun-brig, which lay about nine miles from Vera Cruz, the same means preserved the health of the crew when other ships of war anchored around him lost from twenty to fifty men each; and although constant communication was maintained between the Recruit and the other vessels and all were exposed to the

same external causes of disease, no case of sickness occurred on board the Recruit."

There is but one remedy for this excessive humidity of the air on the decks—dryness. As the humidity has its causation in the constant wetting, arrest the cause. Lacquer all decks below the spar-deck; keep clean; keep dry; dry everywhere below decks, from the bilges and limbers upward. Once a month would be sufficient for all such cleaning purposes as are now suggested to keep alive this abomination. To admit that there are no other means but this daily washing, scrubbing, &c., of securing cleanliness is an exhibition of ignorance and the worship of dirt.

I am well aware that an order directing such a degree of dryness and cleanliness which might be secured by lacquering the decks and other means, with the abandonment of this vestige of the Deluge, would be met with evasion and subterfuge, and that no effort would be spared to render it nugatory and valueless. The writer speaks with a quarter of a century's experience and recorded observation of the failure of various reforms devised for the better sanitary condition of ships.

It has been sought in this fragment to present a few from the many recognized facts entering into the composition of healthy homes on shore to the production of healthy homes afloat. The broad principles of sanitary science apply alike at sea and on shore—masses in limited space, impure air, humidity, &c., agents destructive to health—to reduce to their lowest possible values all the factors that produce this insanitary environment. This is the present paramount duty of every naval medical officer, who should remember, with Richardson, that "pure air, freedom from dampness, pure water, sunlight, and an equable temperature are the five fingers on the right hand of Health."

Two of the most potent of disease-producing agencies have been demonstrated and the means of relief suggested. In one instance such relief is an accomplished fact, and for the future a better ventilation is assured. Dryness must follow. The one means of relief is a solved mechanical problem; the relief of the other is within the province of regulation. It is within bounds to state that the present sick-rates of the service can, by attention to sanitary measures, be reduced one third, or perhaps one-fourth. By law the commanding officer is ostensibly held responsible, amidst other things too numerous to mention, for the health of the crew intrusted to his command. To hold him to such responsibility, however, presupposes a knowledge on his part of all that relates to the etiology of disease—a degree of omniscience that is paralyzing. Such supposition is a self-evident fallacy.

Naval sanitation should be a matter of regulation. A subject so materially affecting the health of the service rests upon officers of all grades and corps, but more particularly does it belong to the daily scrutiny and vigilance of the medical officer as part of the duty he owes the state, and it is alike the duty of the state to promote the sanitary interests, especially in her military establishments.

I trust to see the day when a holy-stone will be looked upon as a curiosity, and its temple, the sand-locker, vanished from off the face of the deep. Then with improved sanitary surroundings will come an efficiency from better health, and arising from these a discipline more consonant with enlightenment than the semi-civilized code that now obtains.

No one is better aware than the writer how imperfect this sketch has been drawn. He has no opinion upon these matters other than those founded upon fact. He is also well aware how difficult it is to discuss separately all the meteoric phenomena of the air on account of their intimate correlation; the mere variation of a degree in the temperature, for instance, at once introducing new relations between man and the great aerial ocean in which he "lives and moves and has his being," but he nevertheless believes that the study of such relations is useful to mankind as tending to wrest from Nature the secrets she still holds of the telluric origin of those perversions of the economy which we call disease. At the invocation of her worshipers, slowly but surely does the Goddess of Health, the daughter of Æsculapius, stretch forth her beneficent hands alike to welcome and protect her wandering children—

Omnibus ab oris maribusque.

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